But, in the case of the Angiospermic anthers, we conclude, on comparative grounds, that progressive septation has taken place; this would indirectly support the view that the sorus of *Danœa* is also a result of progressive septation.

Obviously such a series of stages as that presented by *Danœa* may be read either way, and it would be possible to urge that in them we have evidence, not of progressive septation, but of fusion of loculi. This question must be considered on grounds of general probability. Without at the moment declaring a final opinion (though I think the probability is largely in favour of a view of progressive septation), this point, at least, seems clear: *that in Danœa the identity of the sporangium or loculus is not strictly defined.* To arrive at this point is, in my opinion, a matter of some importance; the study of the sporangium in Pteridophyta has long been based upon the examination of the highly specialised and strictly constructed sporangium of the Leptosporangiatæ. The conclusion is, however, becoming obvious that such strictness of construction and regularity of segmentation is exceptional, and that in the Eusporangiatæ such strictness is not the rule.

Other Marattiaceæ, and especially *Kaulfussia*, have also been examined, and they are all found to conform to one fundamental type, though differing in detail; it appears that, as regards the sorus, *Danœa* is the least specialised, and *Angiopteris* the most specialised, of the living genera, and that they form a very natural series. Such a series in plants of so antique a stock deserves the most careful comparative study, and the results should carry unusual weight.

III. "On the Weight of a Cubic Decimetre of Water at its Maximum Density." By D. MENDELÉEFF, For. Mem. R.S. Received October 16, 1895.

The investigations of Sir George Shuckburgh Evelyn, published in the year 1798,[*] after allowing for the new measures made by Captain Kater,[†] as well as for all corrections according to our present knowledge of the weight of a litre of air and on the expansion of water, give the result that the weight of a cubic decimetre of water at its maximum density ($4°$ C.) *in vacuo* is equal to 1000·56 grams.[‡] But in these investigations the separate determinations show differences of

[*] 'Phil. Trans.,' 1798, p. 133.

[†] 'Phil. Trans.,' 1821, Part II, p. 316.

[‡] All these corrections are made in D. Mendeléeff's paper (in Russian) in the *Vremennik* (Bulletin) of the Central Chamber of Weights and Measures (Chambre Centrale des Poids et Mesures), Part II, pp. 11—19. (*Vide* 'Journal of the Russian Physico-Chemical Society,' 1895.)

± 0.27 gram, and as the water used was not sufficiently pure (having a density of about 1.0005), the above-named result is to be considered as of small accuracy and doubtless much in excess of its real weight. Nevertheless, from these determinations, assuming the density of the water used by Shuckburgh[*] to be as above mentioned, one may conclude that the probable weight is 1000.06 ± 0.14 grams, which comes very near to the real weight of the cubic decimetre, the small difference arising in all probability from the insufficient accuracy of the temperature measurements near 62° F., at which the weighings were made.

It is well known that at the institution of the metrical system at the end of the eighteenth century, the weight of the kilogram was declared to be equal *in vacuô* to the weight of a cubic decimetre of water at its maximum density.   For this purpose M. Lefèvre-Gineau made an exhaustive investigation, upon which M. Tralles made a report on the 31st May, 1779 (*le* 11 *prairial, an* 7), first published in ' Base du Système Métrique,' Tom. III, pp. 558—580, in the year 1810; the original observations of Lefèvre-Gineau are, however, still unknown.   From the data given in Mr. Tralles' report M. Broch found in 1873[†], after making the necessary corrections, that the probable weight deducible from the data of the experiments lies between the limits from 999.913 to 999.947 ± 0.020 grams.   I have myself made a new reduction[‡] of the data given by Tralles and Gineau, the result being 999.966 ± 0.03 grams.   But to this result also we cannot attribute any particular importance, principally for the three following reasons :—1. The original observations of Lefèvre-Gineau are unknown.   2. The cylinder employed by Lefèvre-Gineau in the numerous (altogether forty-eight) weighings at $+0^\circ.3$ C. had a special small tube providing a communication between the inner part of the cylinder and the outer air ; there existed consequently on the inner walls of the cylinder a condensation of aqueous vapour. 3. No particular indications are given as to the methods of purifying the water in which the weighings were made, but considering the fact that water once distilled without special precautions (as an experiment shows) very often has a specific gravity up to 1.0002, taking that of pure water as unity, we may admit that the true weight will be smaller than that obtained from Lefèvre-Gineau's investigations.

From the above-mentioned determinations we must conclude that the weight of a cubic decimetre of water *in vacuo* at 4° C. is not greater than 999.96 grams, and hardly smaller than 999.76 grams.

Of all the determinations made during the present century only

* Shuckburgh, ' Phil. Trans.,' 1798, p. 155.

† ' Procès-verbaux d. Comité international,' 1873—1874, pp. 122—140.

‡ For details see footnote ‡, page 143.

those of M. Kupffer and Mr. Chaney have been carried out under all possible conditions necessary for obtaining reliable results, those conditions being as follows:—Direct comparisons of the weights and measures used with the primary standards of weight and measure, accurate corrections of the thermometers, and particularly care in obtaining entirely pure water, which before the experiment was boiled so as to remove the dissolved air.* I therefore consider these determinations, introducing into them all corrections in a manner corresponding to our present experience, upon which I consider it here necessary to make the following statements. I have assumed:—

1. One metre $= 39\cdot3700 \pm 0\cdot0001$ English inches, as it follows from the combined reliable comparisons of Kater, Clark, and Tittmann. It may be remembered that the Russian inch, according to the law, is equal to the English inch, and that 1 cubic inch appears to be equal to $16\cdot38716$ c.c. or $0\cdot01638716$ cubic decimetre.

2. One pound avoirdupois $= 453\cdot59243$ grams, as we see by the recent comparisons of Mr. Chaney; therefore 1 grain $= 0\cdot0647989$ gram.

3. One Russian pound $= 409\cdot5120 \pm 0\cdot0005$ grams, as appears from the fact that Kupffer gives $409\cdot51156 \pm 0\cdot00072$, and the preliminary weighings made at the Central Chamber of Weights and Measures in 1894 give $409\cdot51236 \pm 0\cdot00022$ grams. Therefore 1 doli (a Russian pound contains 96 zolotniks à 96 dolias) $= 0\cdot0444349$ gram.

4. For pure water (freed from dissolved air) I assumed that the change of the specific gravity (at $4°$ C. $= 1$) as depending upon the temperature $t°$ C. is represented by the following equation :—

$$S_t = 1 - \frac{(t-4)^2}{1\cdot9\,(94\cdot1+t)\,(703\cdot5-t)}, \quad \cdots\cdots\cdots\cdots \text{(I)}$$

as derived by me† from the whole of the best determinations between $-10°$ and $+200°$, made up to the year 1891, verified mercurial thermometers being used, as employed by Mr. Kupffer and Mr. Chaney. Here I consider it necessary to mention that at ordinary temperatures mercurial thermometers always give higher readings (t) than those of the hydrogen thermometer (denoting its temperature by T) ; the difference $t-$T is very various, being at $20°$ from

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* Through the dissolved air the density of water decreases in its millionth parts, as I have shown in my paper, "Investigations on the Specific Gravity of Aqueous Solutions," 1887, p. 383. Maly and Marek ('Wiedemann's Ann.,' 1891, vol. 44, p. 172) actually found this, having shown that the relative density of water containing air at $0°$ C. $= 0\cdot9999975$, at $10°$ C. $= 0\cdot9999968$, at $20°$ C. $= 0\cdot9999996$ and at $30°$ C. $= 1$.

† 'Phil. Mag.,' 1892, p. 99.

$+0.1°$ (*verre dur franç.*) to $+0.25°$ (ordinary easily fusible glass).
Expressing the temperature on the hydrogen thermometer scale as T
and using the latest determinations of Messrs. Thiesen, Maly and
Marek, Scheel, and Chappuis for temperatures from $0°$ to $T = 30°$,
I obtained* the following relation, which well satisfies the best
determinations :—

$$S_T = 1 - \frac{(T-4)^2}{122420 + 1130.2\ T}, \quad \ldots\ldots\ldots\ldots (II)$$

But the specific gravities of water, S_t, we have to take according
to formula I and not II, as Messrs. Kupffer and Chaney give the tem-
peratures on the mercurial thermometer scale without reduction to the
hydrogen thermometer.   As an illustration we give the following
comparison :—

<div align="center">

Mercurial thermometer (I).

</div>

$t = 10°$ C.	$S_t = 0.999738$
$t = 15°$	$= 0.999152$
$t = 16\frac{2}{3}°$ C. $= 62°$ F.	$= 0.998890$
$t = 20°$	$= 0.998272$

<div align="center">

Hydrogen thermometer (II).

</div>

$T = 10°$ C.	$S_T = 0.9997308$
$T = 15°$	$= 0.9991319$
$T = 16\frac{2}{3}°$ C. $= 62°$ F.	$= 0.9988681$
$T = 20°$	$= 0.9982348$

5. The weight of a litre of dry air, freed from carbonic acid at $0°$ and
a pressure of 760 mm., according to my deductions† from the corrected
data of Messrs. Regnault, v. Jolly, Leduc, and Lord Rayleigh, is equal
to $e_0 = g\ 0.131844 \pm 0.0001$ gram, where g is the force of gravity
in metres (accepted 9.8126 for London, 9.8100 for Paris, and 9.8188
for St. Petersburg).   Assuming 0.04 per cent. of carbonic acid we
have for St. Petersburg, $e_0 = 1.2948$, and for London, $e_0 = 1.2940$,
or at the aqueous vapour pressure in the air $= h$ mm., the barometric
pressure at $0° = $ H, and the temperature t, I have assumed that the
weight of a litre of air :—

$$e = e_0\ \frac{H - 0.37\ h}{760\ (1 + 0.00367\ t)}\ .$$

In all of the above mentioned assumptions we have certainly some
errors, but all of them taken together in the extreme case cannot

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* 'Bulletin of the Central Chamber,' &c., Part I, 1894, p. 86.
† *Ibid.*

exceed more than decimilligrams of the weight of a cubic decimetre of water.

A detailed description of a great series of the determinations made by Kupffer we find in vol. 2 of his memoir, 'Travaux de la Commission pour fixer les Mesures et les Poids de l'Empire de Russie' (St. Pétersbourg, 1841). Kupffer used two brass cylinders, the volume of which from a number of measurements as a mean was found to be at $t = 13\frac{1}{3}°$ R $= 62°$ F. $= 16\frac{2}{3}°$ C.,

For the small cylinder, $V_1 = 24·17753$ cubic inches (*loc. cit.*, p. 133).
   ,,   large   ,, $V_2 = 49·89931$,,   (*loc. cit.*, p. 250),

The coefficient of expansion of the brass used was not actually determined by Kupffer, and for the reduction of the volumes at temperatures near $16\frac{2}{3}°$ C. I have, therefore, used the results of Fizeau. From the coefficient of linear expansions (in degrees Celsius) we find for the volumes,

$$v_t = v_o (1 + 0·00005337\ t + 0·00000003\ t^2),\ \ \ldots\ldots\ldots\ (III)$$

therefore for the coefficient of cubic expansion,

$$\left(\frac{\delta V t}{\delta t}\right)\ \text{at}\ 16\tfrac{2}{3}°\ \text{C.} = 0·00005437\ \text{for}\ 1°\ \text{C.},$$

or $$= 0·00006796\ \text{for}\ 1°\ \text{R.}$$

The volumes of both cylinders at $t°$ Réaumur will be,

For the small cylinder, $V_{1_t} = 24·17753 + 0·001643\ (t - 13\tfrac{1}{3})$.
   ,,   large   ,, $V_{2_t} = 49·89931 + 0·003391\ (t - 13\tfrac{1}{3})$.

For the determinations of the diameters and heights of the small cylinders we rarely find a maximum difference between the separate measurements amounting to $0·00014$ inch. From the mean results of a large number of measurements, we must assume that the error in volume determination was not greater than $\pm 0·00168$ cubic inch, or less than the $1/14391$ part of the total volume, which for a cubic decimetre corresponds to $0·069$ gram. In the measurements of the large cylinder having a diameter of about 4 inches, a greater accuracy has been obtained, so that the average error of the linear measurements was smaller than $0·00005$ inch; therefore the error in volume was smaller than $0·000190$ cubic inch, corresponding to a relative error of less than $1/26263$, or for 1 cubic decimetre less than $0·038$ gram. We must therefore expect a greater accuracy from the determinations by means of the large cylinder than from those where the small cylinder was used.

Although I have made in similar detail a new reduction of all Kupffer's data, in the further discussion I shall take into considera-

tion only the data obtained by means of the large cylinder, especially
as in all instances relating to the weighings they are much more
reliable and symmetrical, that is to say, the changes of weight
follow uniformly with the changes of temperature.

With the large cylinder (as with the small) Kupffer made many
series of alternate weighings in air and water. He first used ordi-
nary once distilled water, and afterwards water which was especially
prepared for him by the well-known chemists, Hess and Fritzsche.
According to all test proofs this water appeared to be pure, and
before the experiment it was boiled to remove the dissolved air.
Only data given for pure water are of the greatest importance.
From the data obtained with the water first used we can only con-
clude that its density in relation to that of pure water appeared to
be 1·000128, if we judge from the corrected weighings of the large
cylinder. We expect therefore to find that the weight of a cubic
decimetre, using ordinary once distilled water, may give an increase
amounting to decigrams.

The weight of the large cylinder in air was determined by thirty-
five weighings, distributed in six series, the mean results of which
are :

Number of weighings.	The mean observed weight in arbitrary units, A.*	Readings of barometer at 0° in inches.	Corrected tempera- ture in degrees R.	Psychro- metrical difference in degrees R.	Kupffer, vol. ii.
10	25560·9621 A	29·81	12·30°	—	page 275
5	25561·0171† „	29·77	13·45	3·17°	„ 280
5	25560·8851 „	29·98	12·30	3·61	„ 284
5	25560·6791 „	29·97	12·20	2·80	„ 289
5	25560·4155 „	30·45	13·30	3·00	„ 293
5	25560·7482 „	29·90	13·40	—	„ 307

The results being so remarkably close to one another, we are per-
mitted to take the mean : Weight in air, 25560·7884 A, $H_0 = 29·98$
$= 761·48$ mm.; h (pressure of aqueous vapour, humidity 61 per cent.)
$= 8·26$ mm.; $t = 12·825°$; R. $= 16·03°$ C. Hence we find e (weight
of litre of air) $= 1·2205$ grams, or the weight of a cubic inch of

* For the weighings Kupffer used the working pound D with its verified sub-
divisions, and only at the end of his investigation, as shown later on, established
the relation of this pound to the standard Russian pound N ; the result being
$A = 1·00000933$ dolias of a Russian pound.

† In the computation of the mean for this observation in Kupffer's paper there
is a misprint or error; it is printed 2 lb., 74 zol., 35 ·0171 dolias, but it should be
2 lb., 74 zol., 25 ·0171 dolias $= 25561 ·0171$ A.

air $= 0·4501$ A, the volume of the cylinder $= 49·898$ cubic inches, and the volume of the weights $= 8·156$ cubic inches (sp. gr. $= 8·51$, therefore volume of 3134 A weights $= 1$ cubic inch), we have for the weight of the cylinder *in vacuo*, $P_2 = 25579·5725$ A.* As the arbitrary unit of weight A, as we shall see later on, weighs very nearly the same as a dolia of a pound, that is to say about $44·4$ millirgams, and as the error of Kupffer's weighings is not less than $0·7$ milligram, we can assume the error in P_2 to be $\pm 0·012$ A, and in the mean result an even smaller error will be obtained.

Having finished all his weighings, Kupffer (*loc. cit.*, p. 342) determined the relation of the weight of the arbitrary units A, by means of which the weighings were made, to the weight of a standard Russian pound, and after application of all necessary corrections, he came to the conclusion that A was a little heavier than a dolia of true weight, namely, $A = 1·00000933$ dolia. Therefore $P_2 = 25579·81$ dolias.

Kupffer made twenty-seven weighings of the large cylinder in water, which, although distilled, subsequently appeared to be not quite pure. All these weighings I have re-computed,† but I give here only the final result, showing that at $13\frac{1}{3}°$ R., the weight of the displaced water (reduced to weighings *in vacuo*) is equal to $18382·00$ dolias, which is evidently more than the weight ($18379·19$ dolias) of the same volume of quite pure water prepared by Hess and Fritzsche. After having obtained this water, Kupffer made in it twenty new full weighings of the same cylinder, arranging them in five series of four weighings each, the mean result of which we give here, not in the order of the weighings as made, but in the order of the observed temperatures of the water, so that the change of the relation between the weight and the temperature (t) and the symmetry of the obtained results may be apparent.

	Corrected temperature on the mercurial thermometer scale (Reaumur).	Mean weight of the cylinder in water, in arbitrary units A.	Kupffer, vol. ii.
(1)	$12·73°$	$7200·2738$ A	page 322
(2)	$12·79$	$7200·2628$,,	,. 301
(3)	$13·65$	$7202·4443$,,	,, 320
(4)	$13·84$	$7202·8940$,,	,. 316
(5)	$13·99$	$7203·1370$,,	,, 310

These weighings were made during the intervals between the weighings of the cylinder in air, and therefore for the correction for the weight of air displaced by the weights, we can take the above-

* Kupffer finds the weight *in vacuo* to be $25580·7751$ or $25580·5302$, taking the weight of a litre of air according to Biot and Arago, that is, higher than it should be. For this reason Kupffer's results are larger.

† *Vide* note ‡ p. 143.

mentioned weight of a cubic inch of air $(= 0.4501 \, A)$, and as the volume of the weights $= 2.298$ cubic inches, the correction of the observed weight, in order to obtain the real weight, will be $= -1.0343 \, A$; or if we wish to express this weight in true dolias of a Russian pound, we have to multiply the obtained numbers by 1.00000933. The weight so corrected is given in the first column (I) of the following table; in the second column (II) we find the weight pt of the displaced water, namely, the difference between 25579.81 dolias and the numbers of column II, corresponding to the temperature $t°$ R. (column III).

In order to find the weight P of water displaced by the cylinder at $13\frac{1}{3}°$ R., we have evidently to multiply pt by the relation of the specific gravity of water at $13\frac{1}{3}°$ R. $(= 0.998890)$ to the specific gravity S_t at $t°$ and by the relation of the volumes at $13\frac{1}{3}°$ R. to the volumes at $t°$ R., the latter relation being equal to

$$\frac{1}{1 + 0.00006796 \, (t - 13\frac{1}{3})} \, ,$$

therefore, $$P = \frac{p_t \, . \, 0.998890}{S_t [\, 1 + 0.00006796 \, (t - 13\frac{1}{3})\,]} \, .$$

The values of P are given in the last (V) column, and in column IV those also of S_t according to formula I.

Corrected weight of the cylinder in water in dolias. I.	Weight of displaced water in dolias; p_t. II.	Temperature. Réaumur. III.	Specific gravity of water at $t°$ R. IV.	Weight of water displaced at $13\frac{1}{3}°$ R. P in dolias. V.
1. 7199·31	18380·50	12·73°	0·999013	18378·99
2. 7199·30	18380·51	12·79	0·999001	18379·14
3. 7201·48	18378·33	13·65	0·998824	18379·20
4. 7201·93	18377·88	13·84	0·998782	18379·23
5. 7202·17	18377·64	13·99	0·998749	18379·40
			Mean	18379·19 dolias

The numbers of the last column show a slight increase with rising temperature t, which, without doubt, results from the circumstance that the real coefficient of expansion of the cylinder was smaller than the accepted (0.00006796 for $1°$ R.), but in the mean result this error must disappear, as the extreme temperatures ($12.73°$ and $13.99°$) are almost equally distant from $13.33°$, and as all the differences P are not considerable.*

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* Supposing that $p_t = P + a \, (t - 13\frac{1}{3}) + b \, (t - 13\frac{1}{3})^2$, I have calculated, as did

The weight (*in vacuo*) of the water at $13\frac{1}{3}°$ R. being $= 18379·19$ dolias, and the volume at the same temperature $= 49·89931$ cubic inches, then the weight of a cubic inch $= 368·3255$ dolias (Kupffer found 368·341 dolias and accepted 368·361 dolias) $= 16·366507$ grams at $13\frac{1}{3}°$ R. Therefore, according to the above-mentioned relation between inches and the metre, the probable weight, *in vacuo*, of a cubic decimetre of water at its maximum density is equal to :—

$$\frac{16·366507}{0·998890 \,.\, 0·01638716} = 999·8495 \text{ grams.}$$

This value is not only more reliable than those of Shuckburgh and Lefèvre-Gineau, because really pure water was here used for the first time and all means employed for obtaining a correct result, but this value is also more probable than all the other results obtained by Kupffer.* It corresponds to pure well-boiled water and to the largest of the cylinders employed by him ; so that all the data here show a more evident uniformity than in the other Kupffer determinations.

This result, from observations made forty-five years ago by the Russian metrologist, obtains special importance in consequence of the publication in 1892 in the 'Phil. Trans.' (vol. 183, pp. 331—354) of investigations on the weight of a cubic inch of water, made in the year 1888 by the contemporary English metrologist, Mr. H. J. Chaney, because the latter not only took care to obtain quite pure water (and by boiling removed the dissolved air), not only employed apparatus and methods carefully tested, but also took a cylinder and a sphere of considerably larger dimensions than the largest used by Kupffer.† By its especially large dimensions (about

Kupffer, the most probable value of P, the result being identical with the P above found ; but I consider it more regular to proceed in the way I have accepted, because in the same all entering values, especially S_t, have a real meaning, and because I have also used this method in the discussion of Mr. Chaney's observations.

* Thus, after a full computation of the other determinations of Kupffer, I obtained for the weight *in vacuo* of a cubic inch of water at $13\frac{1}{3}°$ R. from the data :

For the small cylinder, first water		368·389 doli.
„	„	pure „	368·377 „
„	large cylinder, first water		368·371 „
„	„	pure „	368·326 „

† Besides the cylinder C and the sphere S, Mr. Chaney also made measurements with a quartz cylinder Q. After having received from Mr. Chaney some additional data relating to these measurements, I have made a full computation, and found for the cubic decimetre of water at its maximum density, the weight 999·374 grams. To this value I cannot attribute any importance, as the volume of Q is very small, only 23·04 cubic inches, and as quartz very slowly assumes the temperature of the surrounding medium.

9 inches diameter and height) the cylinder C was distinguished, the volume of which at 62° F. $= V_{62} = 572 \cdot 80365$ cubic inches. The cylinder was made of gun-metal, and we have for the same, according to Fizeau's determinations :—

$$v_t = v_0 \left(1 + 0 \cdot 00005106 \; t + 0 \cdot 00000003 \; t^2\right),$$

where t is expressed in degrees Celsius; or, if we start from V_{62} and use the Fahrenheit scale, we have :—

$$V_t = V_{62} \left[1 + 0 \cdot 00002890 \; (t - 62) + 0 \cdot 000000009 \; (t - 62)^2 \right] \ldots \text{(IV)}$$

The weighings in air gave :—

Weight in air in grains.	Temperature of air.	Barometer at 0°.
183676·336	57·5° F.	29·98″
·259	57·3	29·98
·248	60·1	30·22
·302	58·2	29·34
Mean . 183676·286	58·27° F.	29·88″

The specific gravity of the weights was 8·0298. Assuming the humidity $= 66 \cdot 7$ per cent., we have for the weight of a litre of air $1 \cdot 2216$ gram, or the weight of a cubic inch $0 \cdot 3089$ grain, and therefore the weight of C, *in vacuo*, $P_0 = 183825 \cdot 243$ grains.

Six weighings in water, arranged according to the temperature of the water, gave :—

	Temperature of water.	Apparent weight of C in water, in grains.	Temperature of the air.	Barometer at 0°.
1.	56·38° F.	39109·87	56·5° F.	30·22″
2.	57·61	39090·50	56·8	29·38
3.	58·00	39125·00	58·2	29·34
4.	58·10	39109·85	57·2	30·15
5.	58·87	39091·84	56·0	30·14
6.	61·42	38141·86	59·5	30·30

In order to find the weight of the displaced water, first the weight of a cubic inch of air was calculated (column 1), and by this means the true weight of C in water (column 2). After this by subtracting from P_0 the weights p_t of the displaced water (column 3) at the temperatures $t°$ F. (column 4), from these data, knowing the specific gravity of the water S_t (column 5), the weight P of the water at the mean temperature 58·4° F. was calculated, using the formula :—

$$P_{58 \cdot 4} = \frac{p_t \cdot 0 \cdot 999201 \; V_{58 \cdot 4}}{S_t V_t},$$

where 0·999201 is the specific gravity of water at 58·4° F.; $V_{58\cdot4}$ is the volume of C at the same temperature (according to formula IV) and V_t the volume of C at $t°$ F.

Weight of 1 cubic inch of air, in grains.	True weight of C in water, in grains.	Weight of displaced water at t, p_t, in grains.	Temperature in degrees Fahrenheit.	Specific gravity of water at t.	Weight of displaced water at 58·4° F., $P_{58\cdot4}$, in grains.
1.	2.	3.	4.	5.	6.
1. 0·314	39103·82	144721·42	56·38	0·999335	144704·64*
2. 0·305	39084·62	144740·62	57·61	0·999262	144735·13
3. 0·303	39119·16	144706·08	58·00	0·999233	144703·46*
4. 0·312	39103·84	144721·40	58·10	0·999224	144718·90
5. 0·313	39085·81	144739·43	58·87	0·999162	144743·04
6. 0·312	39135·84	144689·40	61·42	0·998895	144733·66

The considerable differences in the numbers of the last column show that in most of the observations there were air bubbles, which Mr. Chaney (*loc. cit.*, p. 347) especially mentions in the discussion of the weighings.   As the air bubbles diminish the weight of C in water, that is to say apparently increase the weight of the water, one must believe that only in two weighings (marked with an asterisk), Nos. 1 and 3, no bubbles, or very few, were shown, and I therefore take for the computation these two weighings only.   According to them, the mean weight of water at 58·4° F. is $P_{58\cdot4} = 144704\cdot05$ grains ; but as the volume of C (according to IV) at this temperature $V_{58\cdot4} = 572\cdot744125$, we have for the weight of a cubic inch of water at 58·4° F. = 252·6504 grains.   The specific gravity of water at this temperature being equal to 0·999201, it follows that the weight, *in vacuo*, of a cubic decimetre of water at its maximum density (4° C.) is equal to 999·8414 grams.

This result, being so close to that (999·8495 grams) deduced from the best observations of Kupffer, shows at once that the method selected by us gives useful results.   It is confirmed by determinations made by Mr. Chaney by means of a brass sphere S, having a diameter of about 6 inches. The volume of the same V_{62} at 62° F. = 112·669406 cubic inches, and according to formula III,

$$V_t = V_{62}[1 + 0\cdot00003018\,(t-62) + 0\cdot000000009\,(t-62)^2].$$

Five very closely accordant weighings of S in air gave a mean weight of 28409·913 grains, at the mean temperature $t = 59\cdot21°$ F., $H_0 = 30\cdot27''$; therefore the weight of 1 cubic inch of air = 0·3123 grain, and the weight of S, *in vacuo*, = 28440·778 grains.

Five weighings in water gave, according to Mr. Chaney's observations and my reductions :—

Temperature of water, t.	Apparent weight of S in water at $t°$, in grains.	Weight of displaced water at t, in grains, p_t.	Weight of displaced water at $56°20'$ F., according to formula V, $P_{56·20}$, in grains.
1. $54·58°$ F.	$-27·02$	$28467·80$	$28466·07$
2. $54·72$	$-27·01$	$28467·79$	$28466·21$
3. $56·63$	$-24·70$	$28465·48$	$28466·11$
4. $57·60$	$-23·72$	$28464·43$	$28466·11$
5. $57·48$	$-23·65$	$28464·50$	$28466·29$

The numbers of the column V are calculated in the same manner as for the cylinder C, namely, according to the formula :—

$$P_{56·2} = \frac{p_t \, 0·999369 \cdot V_{56·2}}{S_t V_t}.$$

The close coincidence between all obtained values of $P_{56·2}$ shows that all the data for S deserve full confidence, which fact Mr. Chaney also fully recognises, and we therefore take the general mean : $P_{56·2} = 28466·16$ grains.

The volume of S at $56·2°$ F. $= V_{56·2} = 112·64972$, and therefore the weight, *in vacuo*, of a cubic decimetre of water at $4°$ C. $= 999·8546$ grams.

As this result is close to the two preceding, we may take a general mean from the three, giving to each of them a weight proportional to the product of the number of weighings and the volume of displaced water, that is to say, proportional to the mass of weighed water :—

	Number of weighings, n.	Approximate volume, in cubic decimetres, p.	Product. np.	Weight of a cubic decimetre of water at $4°$, *in vacuo*, in grams.
Large cylinder, Kupffer..	20	$0·818$	$16·36$	$999·8495 \times 9$
Cylinder C, Chaney......	2	$9·39$	$18·78$	$999·8414 \times 10$
Sphere S, Chaney	5	$1·84$	$9·20$	$999·8546 \times 5$

From these data we find the most probable weight, *in vacuo*, of a cubic decimetre of water at its maximum density to be

$999·847$ grams.

Although the probable error of this result barely reaches the milligrams, it will be most correct to assume that the true value lies between the limits from 999·85 to 999·82 grams, because the method of hydrostatical weighings hitherto used does not guarantee complete absence of air bubbles, but the coincidence between the results of Kupffer and Chaney gives assurance that the probable weight is not larger than 999·85 grams, but possibly a little smaller, about 999·84.

Accepting the above-mentioned value, 999·847, we have :—

Temperature on the hydrogen thermometer scale.		Weight of water *in vacuo*.*		
C.	F.	Of a cubic decimetre, in grams.	Of a cubic inch in English grains.	Of a cubic inch in Russian dolias.
0°	32 ·0°	999 ·716	252 ·821	368 ·686
4	39 ·2	999 ·847	252 ·854	368 ·734
15	59 ·0	998 ·979	252 ·635	368 ·414
16¾	62 ·0	998 ·715	252 ·568	368 ·316
20	68 ·0	998 ·082	252 ·407	368 ·183

Until newer and more accurate investigations upon the expansion of water and its weight in a given volume shall have been carried out, the results discussed must be considered as more accurate than those hitherto published.

IV. "The Measurement of High Potential Difference." By H. C. LEAKE, R. LEVENTHORPE, M.A., and C. S. WHITEHEAD, M.A. Communicated by Professor W. E. AYRTON. Received October 29, 1895.

(Abstract.)

In Part I the question of the measurement of high potential difference in terms of the absolute electromagnetic unit is considered, more especially with reference to the calibration of electrostatic voltmeters.

* In this no account is taken of the compressibility of water, that is to say, it is supposed that the water is under a pressure of 1 atmosphere; but as from this at $t°$ C. (from 0° to 30°) the volume decreases approximately by $50 - 0 ·22t$ millionths parts, we have in real vacuo, at 0°, the weight of a cubic decimetre equal to 999·666 grams, at 20° about 998·036. Therefore, the weight of a cubic decimetre of water reaches 1000 grams under a pressure of 4 atmospheres, but *in vacuo* at all temperatures the weight of water is less than a kilogram.